INTEGRATOR CIRCUIT

CROSS-REFERENCE TO RELATED APPLICATION

[001] The present application claims the benefit of co-pending U.S. Application Serial No. 60/438,153, filed January 6, 2003, by Thomas A. Rodby, entitled: "Integrator Circuit," the disclosure of which is incorporated herein.

FIELD OF THE INVENTION

[002] The present invention relates in general to electronic circuits, and is particularly directed to a new and improved integrator circuit that incorporate a pair of auxiliary/output resistors in the output feedback path of the integrator, that make it possible to more easily realize a desired integration constant with the use of a larger fixed capacitor, thereby minimizing unwanted parasitic capacitor effects. Also, the integration constant can be readily adjusted by implementing the auxiliary resistors as variable components.

BACKGROUND OF THE INVENTION

[003] Integrator circuits are employed in a wide variety of electronic signal processing applications, such as, but not limited to the analog front ends of electrical signal detection and monitoring systems (for example, lightning detection systems). As shown in Figure 1, the basic configuration of a conventional integrator circuit comprises an operational amplifier 10 and a capacitor 15. In the architecture of Figure 1, the operational amplifier 10 has its inverting (-) input 11 coupled to receive an input current I_{IN}, while its non-inverting (+) input 12 is coupled to a reference potential (ground). Capacitor 15 is coupled between input 11 and the amplifier output 13 from which an output voltage V_{OUT} is derived. The transfer function of the integrator of Figure 1 is set forth in equation (1) as:

1 $$V_{OUT}(t) = V_0 - (1/C)\int I_{IN}(t)\,dt \quad (1)$$

[004] From equation (1) it can be seen that the integration constant is inversely proportional to the value (C) of the capacitor 15.

[005] Figure 2 shows a typical variation of the integrator circuit of Figure 1 to accept a voltage input V_{IN}, wherein an input resistor 16 of value R is coupled to the inverting (-) input 11 of the operational amplifier 10. The transfer function of the integrator of Figure 2 is set forth in equation (2) as:

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$$V_{OUT}(t) = V_0 - (1/RC)\int V_{IN}(t)\,dt \quad (2)$$

[006] From equation (2) it can be seen that a much larger variation of the integration constant (1/RC) is available, as two variables R and C can be varied. However, the input resistor is normally selected to provide a prescribed input impedance, so that it is the value of the capacitor that must be varied to realize a given integration constant. A practical problem of the circuit design of Figure 2 is the fact that the capacitor used to set the integration constant is typically available in only discrete values. Therefore, to realize a non-standard value of capacitance for creating a specific integration constant, a plurality of capacitors must be employed. Where a large integration constant is required, it is customary to use a small value of capacitance. When configuring the circuit of Figure 2 with small capacitance values, the impact of parasitic capacitances on circuit performance becomes a design issue.

SUMMARY OF THE INVENTION

[007] In accordance with the present invention, the capacitor-centric problem of a conventional integrator, described above, is effectively obviated by a new and improved integrator design that couples a set of auxiliary/output resistors in the output feedback path of the integrator of Figure 2. In particular, a first

auxiliary resistor is coupled in series with the output of the operational amplifier and the feedback capacitor, while a second auxiliary resistor is coupled between a reference potential terminal (e.g. ground) and the common connection of the first auxiliary resistor and the feedback capacitor. As a result of incorporation of the auxiliary set of resistors, the integrator of the invention has the transfer function set forth in equation (3) as follows:

3

$$V_{OUT}(t) = V_0 - ((R_2 + R_3) / R_1 R_2 C)) \int V_{IN}(t)\,dt \quad (3)$$

where R_1 corresponds to the value of the input resistor, R_2 corresponds to the value of the first auxiliary resistor, and R_3 corresponds to the value of the second auxiliary resistor. As in the case of the circuit of Figure 2, the input impedance of the integrator circuit of the invention is set by the value of the input resistor R1. However, the integration constant now has a pair of additional variables R_2 and R_3 that allow the circuit designer a greater degree of flexibility. This can be particularly advantageous in applications, such as in lightning detection systems, where a change in integration constant may be required (for example, in the case of an approaching storm, it may be desirable to decrease the gain of the integrator, as the storm gets closer to the monitoring site). This is readily accomplished in the integrator of the

invention, by using variable resistors, such as potentiometers, for the auxiliary resistors.

BRIEF DESCRIPTION OF THE DRAWINGS

[008] Figure 1 shows the basic configuration of a conventional integrator circuit;

[009] Figure 2 shows a typical variation of the integrator circuit of Figure 1 to accept a voltage input; and

[010] Figure 3 shows the architecture of the integrator circuit of the present invention.

DETAILED DESCRIPTION

[011] Attention is now directed to Figure 3, wherein a voltage input integrator architecture in accordance with the present invention is diagrammatically illustrated as comprising an operational amplifier 10 having its inverting (-) input coupled through an input resistor 16 of value R_1 to receive an input voltage V_{IN}, and its non-inverting (+) input 12 coupled to a source of reference potential (e.g., ground). An output voltage V_{OUT} is derived from the output 13 of the operational amplifier. Pursuant to the present invention, rather than directly couple feedback capacitor 15 between the output and the input of the operational amplifier, as in the conventional integrator of Figure 2, the feedback path is modified to include a first auxiliary/output resistor 21 of a value R_2, which is coupled in series with capacitor 15 and the operational amplifier output 13. In

addition, a second auxiliary/output resistor 22 of value R_3 is coupled between a reference potential (ground) and the common connection 23 of capacitor 15 and auxiliary/output resistor 21.

[012] As pointed out above, the transfer function of the integrator architecture of Figure 3 is defined by equation (3), restated as follows:

4 $$V_{OUT}(t) = V_0 - ((R_2 + R_3)/ R_1 R_2 C)) \int V_{IN}(t)\, dt \quad (3)$$

[013] With the addition of the auxiliary/output resistors 21 and 22, the present invention makes it possible to more easily realize a desired integration constant with the use of a larger fixed capacitor, thereby minimizing unwanted parasitic capacitor effects, described above. Moreover, the integration constant can be readily adjusted as necessary by implementing the auxiliary resistors as variable components (as shown by the dotted line arrows), such as potentiometers or electronically controlled resistors, such as MOSFETs.

[014] While I have shown and described an embodiment in accordance with the present invention, it is to be understood that the same is not limited thereto but is susceptible to numerous changes and modifications as known to a person skilled in the art. I therefore do not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are obvious to one of ordinary skill in the art.